

VACUUM OVEN DRYING OF PIGEON PEA DHAL [*CAJANUS CAJAN* (L.)]:

EVALUATION OF PHYSICAL AND INSTANT PROPERTIES

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ABSTRACT

Attempts were made to prepare instant whole legume - Pigeon Pea by precooking and drying in oven assisted with vacuum. This paper reports a preliminary study carried out to determine physical and instant properties of instant Pigeon pea dhal. Physical properties like the moisture content, bulk density, drying time of the products are 4-5% (w.b.), 550 kg/m³ and 6-7hrs/100 gm respectively. Instant properties such as dispersibility and solubility ranged from 75 to 80% and 36±0.5 to 41±0.5 ml. Hunter L, a, b values and hedonic test of reconstituted instant dhal were 50.2, +16.53 and +14.53 and overall acceptability of instant and precooked dhal was found to be the same.

KEYWORDS: Drying Time, Instant Characteristics, Instant Dhal & Vacuum Oven Drying

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INTRODUCTION

Red gram [*Cajanus cajan* (L.)] is an important pulse crop in India. It is also known as Pigeonpea, Arhar and Tur. Red gram is mainly cultivated and consumed in developing countries of the world. This crop is widely grown in India. India is the largest producer and consumer of Red gram in the world. Red gram is a protein rich staple food. It contains about 22 percent protein, which is almost three times that of cereals. Red gram supplies a major share of protein requirement of vegetarian population of the country. It is mostly consumed after dehusking and cooking to desirable softness. The dehusked split grain is called “dhal”, after cooking; the food prepared is also called “dhal”. which is an essential supplement of cereal based diet. The combinations of Dal-Chawal (pulse-rice) or Dal-Roti (pulse-wheat bread) are the main ingredients in the average Indian diet. The biological value improves greatly, when wheat or rice is combined with Red gram because of the complementary relationship of the essential amino acids. It is particularly rich in lysine, riboflavin, thiamine, niacin and iron.

Instant foods are convenience products that require very little effort to reconstitute or cook prior to consumption. They range from liquids or semisolids to those that form porridge or stiff dough after due reconstitution. The cooking quality of pigeon pea is primarily assessed by its cooking time. With the increased urbanization and number of working-women, there is a need to develop products that need less preparation time in households. Since pigeon pea requires considerable cooking time, there is a need to have instant pigeon pea dhal. Instant dhal prepared with raw dehusked pigeon pea as main raw material, were soaked in water or in solution containing organic salts followed by cooking and then drying. Instant was done by oven drying of the concentrated dhal (Chakraborty, Kumbhar, and Sarkar, 2006) and the drawbacks of this method, too rapid mass transfer could damage the texture in some cases. At the final stage of drying, product temperature might be increased rapidly to the

level that causes scorching. Whereas in vacuum drying, high energy water molecules diffuse to the surface and evaporate due to low pressure. Because of this, water vapor concentrates at the surface and the low pressure causes the boiling point of water to be reduced. Thus, vacuum drying prevents oxidation due to the absence of air, and thereby, maintains the color texture and flavor of the dried products. To overcome the limitation of oven drying, vacuum assisted oven drying has been used for drying fruits and vegetables. The advantage was to speed up the drying process, to increase mass transfer by an increased pressure gradient between inner and outer layers and to maintain drying process at low temperature (Nantawan and Weibiao, 2009). Therefore, the objective of this work was to determine the physical and instant characteristics of vacuum assisted oven drying of pigeon pea dhal powder. To determine hunterlab color parameters and evaluate sensory attributes of made dhal produced from reconstituting vacuum oven dried dhal.

MATERIALS AND METHODS

The pigeon pea dhal, vegetables like tomatoes and green pepper were procured from the local market. It was cleaned to remove foreign matter and inferior quality.

Preparation of Instant Pigeon pea Dhal

Preparation of Pigeon pea Dhal

The mass ratio of the ingredients used in the experiments was cleaned pigeon pea dhal of 26 %, 66 % of cut and washed tomatoes, green chilies of 5 %, salt of 1 %, turmeric of 0.5% and 1.5 % any edible oil were cooked in three liter pressure cooker. The dhal was prepared using ingredients to water ratio 1:1 (w/w). It was cooked at 15–psi (gauge) steam for different cooking time, which was measured after the three whistles of the pressure cooker. The level of water in pressure cooker and the heat supplied to the pressure cooker were kept constant in all experimental runs. After removing the whistle, the dhal was heated for 5–10 min, so that all the ingredients get mixed. For seasoning, little oil is heated in which 1tsp mustard, 1tsp cumin, 5–6 curry leaves and 2–3 red chillies were added. The dhal was added to the seasoning. The control sample was prepared by cooking raw pigeon pea dhal with water of 1:2 (w/w) ratio and without ingredients for comparison.

Experimental Equipment

Vacuum-oven drier is a horizontal Double Walled cylinder made of stainless steel with a transparent window of toughened glass is provided at the front to see through. Heating elements are made of high quality Nichrome/Kanthal wire are embedded around the chamber. Temperature is controlled by Microprocessor Based Digital Temperature Controller cum indicator from 50°C to 130°C \pm 2°C. Fitted on front panel. Vacuum-oven drying experiments were carried out in the department of Food process engineering, Vaugh School of Agricultural Engineering, Sam Higginbottom Institute of Technology and Sciences, Allahabad.

Experimental Procedure

The prepared dhal was poured in a metallic vessel. Prior to vacuum-oven drying the samples were weighed on a laboratory scale and placed in stainless steel utensils. The samples were placed in the chamber of vacuum oven and then the vacuum pump was turned on. Heating was started when the vacuum level reached the 3 mm of Hg and stopped when reached 80°C. The pressure and temperature were maintained constant throughout the drying process. Moisture loss of samples was measured by periodically taking out and weighing the dish on a digital balance.

Analysis of Sample

Physical Properties

Moisture content was determined gravimetrically, 5 g sample was weighed accurately and subjected to oven drying at 110°C for 4-5 h. Oven dried samples were cooled in desiccators and weighed. The drying was repeated until the constant weights were obtained. The resultant loss in weight was calculated and percent moisture content has to be determined, on wet basis, using the following formula.

$$\text{Moisture content (w.b)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

Where, W_1 = weight of empty moisture box, g, W_2 = weight of moisture box + dhal sample, g, W_3 = weight of moisture box + dried dhal sample, g. Moisture content was also determined in terms of dry basis, using the following formula.

$$\text{Moisture content (d.b)} = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100$$

The experimental moisture content data were non-dimensionlized using the following equation to express the changes of moisture during drying:

$$MR = \frac{(X_t - X_e)}{(X_0 - X_e)}$$

Where, MR is the dimensionless moisture ratio, X_t is the moisture content (w/w, d.b.) at time t, X_0 is the initial moisture content (w/w, d.b.), X_e is the equilibrium moisture content (w/w, d.b.), and t is the drying time (h).

Total Drying Time

The total drying time was determined from the beginning of vacuum-oven drying to the final moisture content of dried samples i.e., 4% (w.b.).

Bulk Density

Bulk density was determined by adding 20 g of instant powder to a 50 ml graduated cylinder and holding the cylinder on a vibrator for 1 min. The bulk density was calculated by dividing mass of the powders by the volume occupied in the cylinder. (Phoungchandang, and Sertwasana, 2010.).

Instant Properties

Dispersibility

Dispersibility of the sample was determined by dissolving approximately 34 ± 0.1 g of each sample in 250 ± 0.1 g of water, adjusted to $25 \pm 1^\circ\text{C}$ in 600 ml glass beaker graduated at 150 and 250 ml. The mixture was manually stirred continuously for 1 min and then without disturbing any sediment, the liquid quickly poured off down to approximately the 150 ml graduation mark. The decanted liquid was evenly spread over the test sieve of diameter 200 mm, woven metal wire cloth, nominal size of apertures 150 μm , which is fitted with a receiver below. The contents of the receiver transferred to a conical flask by means of the glass funnel. The liquid was dried to obtain two nearest single values, as the total solids

content. ISO: 2011(E). The experiment was performed in triplicate.

Dispersibility was calculated by using following formula

$$D = \frac{735 \times T}{100 - (W + T)}$$

Where D is dispersibility, in %, T is the total solids content, in % (w/w), of the liquid, W is the moisture content, in % (w/w) (w.b.), of the pre-treated test sample.

Solubility Index

The traditional solubility test used worldwide actually measures insolubility. The test involves adding 10g of instant dhal powder to 100ml of water at 25°C with high speed mixing for 90 seconds. The reconstituted dhal is left for 15 min., then the amount of sediment at the bottom of the tube is measured in ml. and is termed solubility/insolubility index (Anup, Atanu and Chavan, 2012).

Color Measurement of Different Dhal Samples

All the reconstituted dhal samples were subjected to color measurement by the method of Hunt (1991). Color was measured and compared using a hunter colorimeter. It was used to measure the L, a, b values. 'L' indicates lightness (L=100 white, and L=0 black), 'a' indicates redness when positive and greenness when negative and 'b' indicates yellowness when positive and blueness when negative.

Sensory Evaluation of Reconstituted Instant Dhal

Instant dhal and control samples were reconstituted with 10 g of the powder were boiled with 100 ml water till they become soft and attained the consistency of cooked product and were analyzed by preliminary sensory panel to determine the sensory attributes of color, flavor/aroma, taste, texture and overall acceptability. A balanced 10-point hedonic rating was employed for all the attributes evaluated where 9-10 denoted "like very much", 7-8 "like", 5-6 "Neutral", 3-4 "dislike" and 1-2 indicated "dislike very much". The judges were asked to give their remarks about each of the samples.

Statistical Analysis

Data were analyzed using the Web Agri Stat Package software (WASP, ICAR Research Complex for Goa, Goa, India). Analyses of variance were performed by the ANOVA procedure. Completely randomized design was followed.

RESULTS AND DISCUSSIONS

Production of Instant Dhal

About 71 g of instant dhal powder with 4-5 % moisture content (w.b) was obtained from 276 g of prepared dhal with 74-76 % moisture content (w.b) i.e., (25.78 %). Whereas 80 g of the control sample with 3-5 % moisture content (w.b) was prepared from 295g of cooked raw dhal with 70-72 % i.e., (27 %). Powders moisture contents were found to be targeted in the range of <5 g/100 g (Siniya & Mishra, 2008). As it is suggested instant dhal powder was dried in the range of 3-5g/100 g to provide better stability during packaging and storage.

Drying Time

Time required in reducing to various moisture levels are presented in table 1. The time of drying needed to reduce

moisture content from the initial point to 4-5% (w.b.), observed almost same for instant dhal and control samples which were dried under similar conditions.

Table 1: Time of Drying Required in Reducing the Moisture Content of Prepared Dhal and Control to the Required Levels

Moisture Content % (w.b)	Time of Drying (Hours)	
	Instant Dhal	Control
70	0.48	0.32
60	2.72	2.61
50	4.25	4.33
10	6.28	5.63
0	6.40	6.42

Drying Kinetics

Drying curves for instant dhal and control were drawn by taking MR (dimensionless moisture ratio) on y-axis and time on x-axis, presented in Figure 1. The pattern of drying in reducing moisture content from the initial point to 4% d.b., observed almost same for instant dhal and control samples dried under similar conditions. This similar pattern was due very less difference in the thermal conductivity of instant dhal with all the ingredients and the control sample without any ingredient.

At 80°C, there is a negligible difference in the thermal conductivity of aqueous NaCl solutions and of pure water (Huseyin and Sidney, 1980).

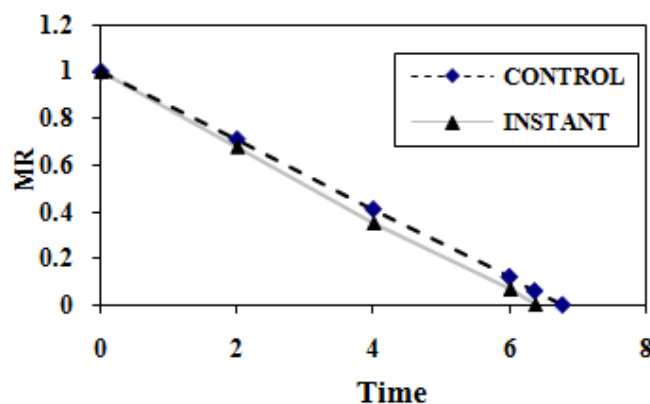


Figure 1: Drying Curves of Instant Pigeon Pea Dhal and Control Sample

Bulk Density

Bulk densities of the powders were presented in table 2. They were found to be 714 kg/m³ for the controls and 550 kg/m³ for the dhal seasoned with ingredients. These values were found to be in range of the bulk density values of instant dhal produced by using pigeon pea (Ghadge, Shewalkar, & Wankhede, 2008).

Table 2: Bulk Densities of Prepared Dhal and Control

Name of the Sample	Weight (g)	Volume (ml)	Bulk Densities	
			g/ml	kg/m ³
Instant dhal	20	28±0.01	0.7	714.2
Control	19.8	36±0.01	0.55	550

Dispersibility

Dispersibility is the ease with which the powder becomes distributed as single particle in the bulk liquid phase. During use, instant dhal is not consumed immediately after reconstitution i.e., allowed to stay a while between ingestion, has tendency to form sediments at the bottom of the container. This reduces the convenience in use, as it would require some intermittent stirring to ensure uniform mouth feel and probably the taste of the reconstituted food. However, when the constituent particles have different color and light dispersion characteristics, dispersibility may equally affect the products appearance. Reconstituted foods that have low dispersibility often have high sedimentation volume, as both are opposite instant properties pertinent to instant powdered food (Park, Imm & Kij, K. H. 2001). The dispersibility were presented in table 3 and the table shows dispersibility of the instant dhal powder was ranged from 75 % to 80% and for control was 78 % to 82 %. From statistical analysis, there is no significant difference in dispersability values of control and instant dhal powders.

Solubility Index

Solubility is an important feature of powders. Poorly soluble powders can cause processing difficulties and can result in economic losses. Solubility is a measure of the final condition to which the constituents of the powder can be brought into solution or stable suspension. Solubility depends mainly on the chemical composition of the powder and its physical state. Solubility of dhal samples are presented in table 4 and were found to be in the range of 36 ± 0.5 to 41 ± 0.5 ml for instant dhal and 32 ± 0.5 to 33 ± 0.5 ml for control samples.

Higher sedimentation value also indicates higher dispersability of particulate matter indicating selectively lesser thermal damage of protein and starch during drying (Ghadge, Shewalkar, & Wankhede, 2008). From statistical analysis, there is significant difference in solubility index values of control and instant dhal powders.

Table 3: Dispersibilities of Instant Dhal and Control Samples

	Sample Name	Total Solids, T%	Average Moisture Content, W%	Dispersibility, D%
Instant dhal	Sample 1	8.89	4.38	75.40
	Sample 2	9.38	4.38	79.95
	Sample 3	8.96	4.38	76.01
Control sample	Sample 1	9.57	4.39	81.78
	Sample 2	9.21	4.39	78.42
	Sample 3	9.61	4.39	82.16

Table 4: Solubility Indices of Instant Dhal and Control Samples

Name of the Sample	Solubility Index, MI	
	Instant Dhal	Control
Sample 1	41 ± 0.5	33 ± 0.5
Sample 2	36 ± 0.5	32 ± 0.5
Sample 3	41 ± 0.5	32 ± 0.5

Color Measurement of Instant Pigeon Pea Dhal

The L, a, b values of different pigeon pea dhal samples are shown in Table A.1.1 and Figure. 2. Control sample was found to have highest L (lightness) and lowest 'a' (redness) values of 66.9 and 7.5 compared to instant dhal with

lowest L (lightness) and highest a (redness) values of 50.02 and 16.53 respectively. The b (redness) values of instant dhal, control and cooked dhal are 14.53, 13.04 and 12.5 respectively. This indicates instant dhal color almost similar to that of cooked dhal.

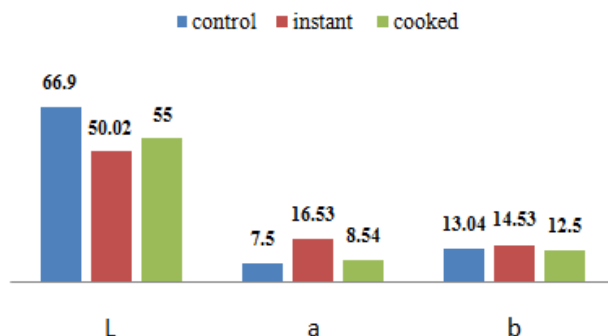


Figure 2: Sensory Characteristics of Instant Pigeon Pea Dhal

Sensory Characteristics of instant Pigeon Pea Dhal

Sensory characterization of instant dhal produced by microwave drying is shown in Tables A.1.2 to A.1.4 and mean scores are graphically depicted in Figure. 3. The mean score values for color of cooked and reconstituted instant dhal was more as compared to control, whereas the values for taste was more as compared to other treatments for cooked dhal by the panelist. As the sensory characteristics are important in consumer point of view, the instant dhal must possess good sensory attributes on the basis of overall acceptability. The mean score values for overall acceptability indicates that instant dhal is similar to that of cooked dhal.

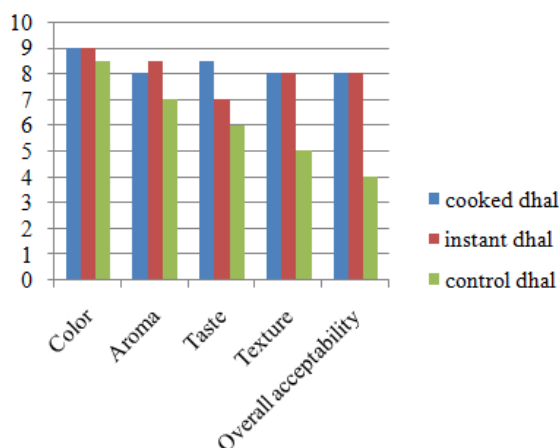


Figure 3: Sensory Scores of Different Dhal Samples

From statistical analysis, except color, all the sensory attributes have significant differences in their values of cooked, control and instant dhal samples.

CONCLUSIONS

Due to increased urbanization and working-women, there is a need to develop food that takes less time in cooking and retains all the characteristics of traditional foods. Pulses are an important part of typical Indian diet due to their

nutritional value. Pigeon pea (*C. cajan*. L) is the second largest pulse crop and is widely consumed in India. It is a hard to cook pulse and takes about 40 to 50 min to get cooked to soft consistency. The present work was aimed at reducing the cooking time of pigeon pea dhal to such an extent that it can be called “Instant Pigeon Pea dhal”. The instant pigeon pea dhal was manufactured by cooking cleaned pigeon pea dhal of 26 %, 66 % of cut and washed tomatoes, green chilies of 5 %, salt of 1%, turmeric of 0.5% and 1.5 % any edible oil in terms of mass ratio in a three liter pressure cooker for three whistles. After removing the whistle the dhal was heated for 5–10 min, so that all the ingredients get mixed. For seasoning little oil is heated in which 1tsp mustard, 1tsp cumin, 5-6 curry leaves and 2-3 red chillies were added. The dhal was added to the seasoning. Control sample was done with water to dhal ratio of 1:2 (w/w).

Vacuum assisted oven drying has been used for making instant whole legume: pigeonpea. Based on the results the following conclusions were drawn.

- About 71 g of instant dhal powder with 4-5 % moisture content (w.b) was obtained from 276 g of prepared dhal with 74- 76 % moisture content (w.b) i.e., (25.78 %). Whereas 80 g of the control sample with 3-5 % moisture content (w.b) was prepared from 295 g of cooked raw dhal with 70-72 % i.e., (27 %).
- The time of drying needed to reduce moisture content from the initial point to 4-5% w.b., observed almost same for instant dhal and control samples, which were dried under similar conditions.
- The pattern of drying in reducing moisture content from the initial point to 4-5% d.b., observed almost same for instant dhal and control samples dried under similar conditions.
- Bulk density of instant dhal powder was 550 kg/m³ for the dhal seasoned with ingredients is less than the controls, found with 714 kg/m³.
- Dispersibility of the instant dhal powder was ranged from 75 % to 80% was less compared to 78 % to 82 % of control.
- Solubility index of instant dhal was in between 36±0.5 to 41±0.5ml was less compared to 32±0.5 to 33±0.5ml of control.
- Control sample was found to have highest L (lightness) and lowest a (redness) values of 66.9 and 7.5 compared to instant dhal with lowest L (lightness) and highest a (redness) values of 50.02 and 16.53 respectively. The b (redness) values of instant dhal, control and cooked dhal are 14.53, 13.04 and 12.5 respectively. This indicates instant dhal color almost similar to that of cooked dhal.
- The overall acceptability of the dhal samples obtained by the mean scores of the sensory attributes is found to be same for cooked dhal and instant dhal.

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APPENDIX

Table A.1.1: Color Measurement of Different Pigeon Pea Samples

Type of the Dhal	L	a	b
Control	66.9	+7.5	+13.04
Instant	50.02	+16.53	+14.53
cooked dhal	55.0	+8.54	+12.5

Table A.1.2: Values of Sensory Evaluation for Cooked Dhal

Sensory Attribute	Panelist 1	Panelist 2	Panelist 3	Mean
Color	8.50	9.00	9.50	9.00
Aroma	7.50	8.00	8.50	8.00
Taste	8.00	9.00	8.50	8.50
Texture	8.00	7.50	8.50	8.00
Overall acceptability	8.50	7.50	8.00	8.00

Table A.1.3: Values of Sensory Evaluation for Reconstituted Instant Dhal

Sensory Attribute	Panelist 1	Panelist 2	Panelist 3	Mean
Color	8.50	9.50	9.00	9.00
Aroma	8.00	8.50	9.00	8.50
Taste	6.50	7.00	7.50	7.00
Texture	7.50	8.00	8.50	8.00
Overall acceptability	8.50	8.00	7.50	8.00

Table A.1.4: Values of Sensory Evaluation for Reconstituted Control Dhal

Sensory attribute	Panelist 1	Panelist 2	Panelist 3	Mean
Color	8.00	9.00	8.50	8.50
Aroma	7.50	7.00	6.50	7.00
Taste	5.50	6.00	6.50	6.00
Texture	4.50	5.50	5.00	5.00
Overall acceptability	4.50	4.00	3.50	4.00

